

**Training Manual for State Environmental Code 1995**  
**Chapter 4**  
**SITE, SOILS AND WATER**

This session is devoted to an evaluation of the site where a subsurface sewage disposal system is proposed for installation. Topics will include: the topography of the lot, the soil in which the system is to be constructed, the presence or absence of groundwater, bedrock or other impervious materials and the investigation of nearby water courses, water supplies, wetlands, flood plains or watershed which might be affected by a proposed sewage system. The session will also devote considerable time to the site plan review and the data and other information needed prior to approval of a permit.

The session will include classroom discussion, together with field inspections and/or slides, transparencies, video tapes or a combination of various media.

**SUGGESTED READING ASSIGNMENTS:**

Title 5: Standard Requirements For The Siting, Construction, Inspection, Upgrade, and Expansion of On-Site Sewage Treatment and Disposal Systems and for the Transport and Disposal of Septage (see Subparts B and C)

EPA Design Manual - "Onsite Wastewater Treatment and Disposal Systems" (see Chap. 2 & 3)

State of the Art Manual of Onsite Wastewater Management, National Environmental Health Association (see Chap. 5 & 6)

An Introduction to Groundwater and Aquifers - Groundwater Information Flyer #1, Nov/Dec 1983, Mass. Audubon Society, So.  
Great Road, Lincoln, MA 01773 (Tel. 617/259-9500)

## **Chapter 4 - SITE, SOILS AND WATER**

### **REVIEWING PLANS FOR PROPOSED SYSTEMS**

When an application for a Disposal System Construction Permit is submitted to the local board of health it must be accompanied by a plan of the proposed on-site sewage treatment and disposal system. Under section 15.220 of Title 5, the following information, at a minimum, must be shown on a plan prepared by a professional engineer, sanitarian, or other professional authorized by law to prepare such plans:

- the legal boundaries of the facility to be served,
- identification of the holder and location of any easements appurtenant to or which could impact the system,
- the location of all dwellings or buildings existing or proposed on the facility and identification of those to be served by the system,
- the location of all existing and proposed impervious areas, including driveways and parking areas,
- the location and dimensions of the system (including reserve area)
- all system design calculations including the design average daily flow, septic tank capacity (required and provided); soil absorption system capacity (required and provided); and whether or not the system was designed with a garbage grinder,
- north arrow and proposed contours,
- location and log of deep observation hole tests including the date of the test, existing grade elevations marked on each test, and the names of the representative of the approving authority and soil evaluator,
- location and results of the percolation test with the same information listed above,
- name and approval number of the soil evaluator of record,

- location of every water supply, public and private
  - a. within 400 feet of the proposed system location in the case of surface water supplies and gravel packed public water supply wells,
  - b. within 250 feet of the proposed system in the case of tubular public water supply wells, and
  - c. within 150 feet of the proposed system in the case of private water supply wells,
- location of any surface waters, rivers, bordering vegetated wetlands, salt marshes, inland and coastal banks, regulatory floodways, velocity zones, tributaries to surface water supplies, certified vernal pools, and surface and subsurface drains or dry wells. Also the location of any nitrogen sensitive area within which portions of the proposed system are located.
- location of any proposed well to serve the lot,
- location of water lines and other subsurface utilities on the property,
- observed and adjusted groundwater elevations in the vicinity of the system,
- identification of all variances sought in conjunction with the plan, including variances from local regulations, and
- complete design plans and specifications for dosing systems and recirculating sand filters, if proposed.

In addition to the above, that are required under Title 5, some other important information should be included on the plans:

- name, address, date, original signature and seal of the design engineer or other legally authorized professional,
- dates of any plan revision and, if other than the original designer, the name, address, original signature and seal of the author of the revised plan,
- North arrow, stating whether it is magnetic, true or assumed North,
- the location of any known fill,
- identify existing structures, old foundations, stone walls, ledge outcrop and any known solid waste disposal areas on the lot,
- invert elevations at foundation wall, inlets and outlets of the septic tank, distribution boxes and all leaching systems

## **SITE VISITS**

It is imperative that a site investigation be made, by the Board of Health, on every lot for which an application and plan to a sewage system is received. No permit should be issued until a site visit is made and the investigation completed. The Board of Health should carefully review the plan and all the data submitted before making a site visit. The board should also review other information, often in its own files, relating to groundwater, bedrock, soil conditions and other pertinent information about the area. Even though the board of health may have been present earlier when percolation tests and deep observation hole examinations were being made, another site visit is warranted if there has been any change in the proposed plans, or important factors relating to the lot were not noted and recorded.

The site should be critically examined to ensure that, not only is the area of the proposed facility free of impediments such as high groundwater, bedrock, surface drainage, etc., but the reserve area is likewise free of such problems. The site visit and investigation offers an opportunity to discover old foundations, fill, solid waste disposal sites, wells on adjoining lots, wetlands, etc., which can have an important bearing on the design and approval of an on-site sewage treatment and disposal system. The type and degree of slope on a lot may have considerable influence on the drainage of the lot and the resulting design of the leaching facility.

## **SOILS OF MASSACHUSETTS**

Soil has different meanings to people in the various professions. To soil engineers, it is earthen material excluding bedrock. The farmer considers soil as a habitat for plants, whereas the homeowner looks at soil as a support for his house and a medium for growing a lawn. The soil scientist considers soil as the upper weathered and biologically molded part of the earth's crust that supports plant growth. Soil consists of a combination of solids, water and air; and generally extends to a depth of 5 feet and is typically underlain by unweathered geologic material. Soil as defined in Soil Taxonomy: "is the collection of natural bodies on the earth's surface, in places modified or even made by man of earthy materials, containing living matter and supporting or capable of supporting plants out-of-doors."

People who have done soil testing within the state know that our soils are variable, often varying dramatically both physically and chemically within the space of a one acre lot. At the present time there are approximately 140 different kinds of soils (soil series) recognized and mapped in Massachusetts. Some of these soils are unique to the area but many are mapped in other states in the Northeast or even outside the region. Soils are generally given geographic names from areas where they were first recognized and mapped. Each soil has a specific range in physical and chemical characteristics that distinguishes it from other soils.

Depending upon the surface texture (percent sand, silt and clay), degree of surface stones, abundance of rock outcrops, steepness of slope, etc., the 140 soil series mapped in Massachusetts are subdivided into more than 1000 different soil phases. Each delineation on a soils map represents a soil phase with specific physical and chemical properties. More than 20 different use interpretations have been made for each soil

phase.

These use interpretations include: agricultural capabilities, septic tank absorption fields, dwellings with and without basements, small commercial buildings, sources for gravel, woodland suitability, etc.

## **SOIL PROFILE**

A soil profile is a vertical cut extending from the upper surface of a soil down through the different soil layers (horizons) into the underlying unweathered geologic material. Soil profiles differ depending upon the type of geologic material they formed in, and the kind and degree of physical and chemical weathering that has taken place. The effects of these different conditions are evident within the soil profile as different horizons, color patterns, textural changes, etc. being able to interpret their significance is an important aspect of any site review. Because of the significance of soil, the code requires that each site be examined and a log of the soils be signed by a approved soil evaluator. Additional training courses specifically designed for soil evaluation are being sponsored by DEP. Upon completion qualified individuals must pass an exam to become certified. For course schedules and additional information relative to this process you should contact your regional DEP service center. A significant portion of this chapter has been dedicated to providing background information relative to the history of soils and more specifically the types of soils typically found in Massachusetts. This information is intended to supplement rather than replace the information obtained during the soils course.

When describing a soil profile, the different layers of soil horizons are noted, and their physical and chemical properties (depth, thickness, color, soil texture, soil structure, etc.) are described and recorded. Depending on the soil, a technical profile description may have 8 or more horizons, and should describe the soil and underlying geologic sediments within the full depth of the deep observation hole. The profile at a deep observation hole preferably should be described using established soil survey terminology. If one is unfamiliar with this, it may also be possible to describe the soil profile using the following non-technical subdivisions: organic mat, topsoil, subsoil, and substratum. If significant changes are observed within these broad subdivisions, they should be identified. It should be noted that these terms often have different meanings in the various professions and their use in this text conforms to the general soil survey terminology (U.S. Department of Agriculture).

The **organic mat** is a surface layer typically comprised of non-decomposed and partially decomposed leaves, pine needles, and twigs. This layer is generally present only in wooded areas. It is dark in color ranging from black to very dark grayish brown. The organic mat typically ranges in thickness from 1 to 6 inches.

The **topsoil** is the uppermost mineral layer and is a mixture of well-decomposed organic matter and mineral material. This layer is generally dark in color ranging from dark brown to brown. Thickness of the topsoil may range from 1 inch to nearly a foot. Typically, there are many fine and very fine roots.

The **subsoil** is the mineral layer that is between the topsoil and substratum. In upland soil

areas it is generally strong brown or yellowish brown in the upper portion and fades with depth to a yellowish brown or pale yellow. The subsoil ranges in thickness from 1.5 to 3 feet and typically extends to a depth of 2.5 to 3.5 feet.

The **substratum** is the mineral layer below the subsoil. Material within the substratum has only been slightly affected, if at all, by soil forming processes and is very similar to the geologic material that was originally deposited. Color of the substratum varies but is typically a very pale brown or light olive gray.

## **EFFECTS OF GEOLOGY ON THE SOILS OF MASSACHUSETTS**

Several periods of glaciation have dominated North America during the last 2 million years. Climatic conditions fluctuated, and during cooler periods more snow fell in the winter than melted during the summer. Vast deposits of snow accumulated in Canada, and as the weight of the overlying snow compressed the underlying snow into ice, the snow-formed glacier gradually crept southward.

During the most recent glacial period, the glacier reached its maximum extent approximately 25,000 years ago and extended as far southward as Nantucket, Martha's Vineyard, Block Island and Long Island. Ice covered all of the land features in Massachusetts and may have been one to two miles thick in some areas. With a gradual warming trend, the glacier began to melt and slowly retreated northward. It is believed that the ice disappeared completely from Massachusetts between 12,000 to 14,000 years ago.

Vast areas of barren, unconsolidated mineral deposits were exposed as the glacier receded northward. Eventually, a vegetative cover was established on the glacial deposits. Over the last 12 to 14 thousand years to the present, these deposits have been subjected to the influence of percolating water, alternating wetting and drying, and freezing and thawing cycles. These varying physical and chemical processes altered the upper surface of the glacial deposits and formed the soils that we see today.

On the geologic time scale (10,000 to 14,000 years) the soils in Massachusetts can be considered to be young soils. Some of the changes that have taken place since glaciation include: the addition of organic matter to the soil, color development within the subsoil, breakdown of easily weatherable minerals, and mixing of the top soil and subsoil through physical and biological activity. These changes for the most part have not significantly altered the original geologic material. Knowing the type of geologic material that a soil formed in, referred to as parent material, plays a significant role in understanding the physical and chemical properties of a particular soil.

## **PARENT MATERIAL**

Parent material is the unconsolidated organic and mineral material in which soils formed. The major kinds of soil parent materials recognized in Massachusetts are: glacial till, shallow to bedrock areas, glacial outwash, glacial lakebed sediments, marine sediments, organic deposits, and alluvial deposits.

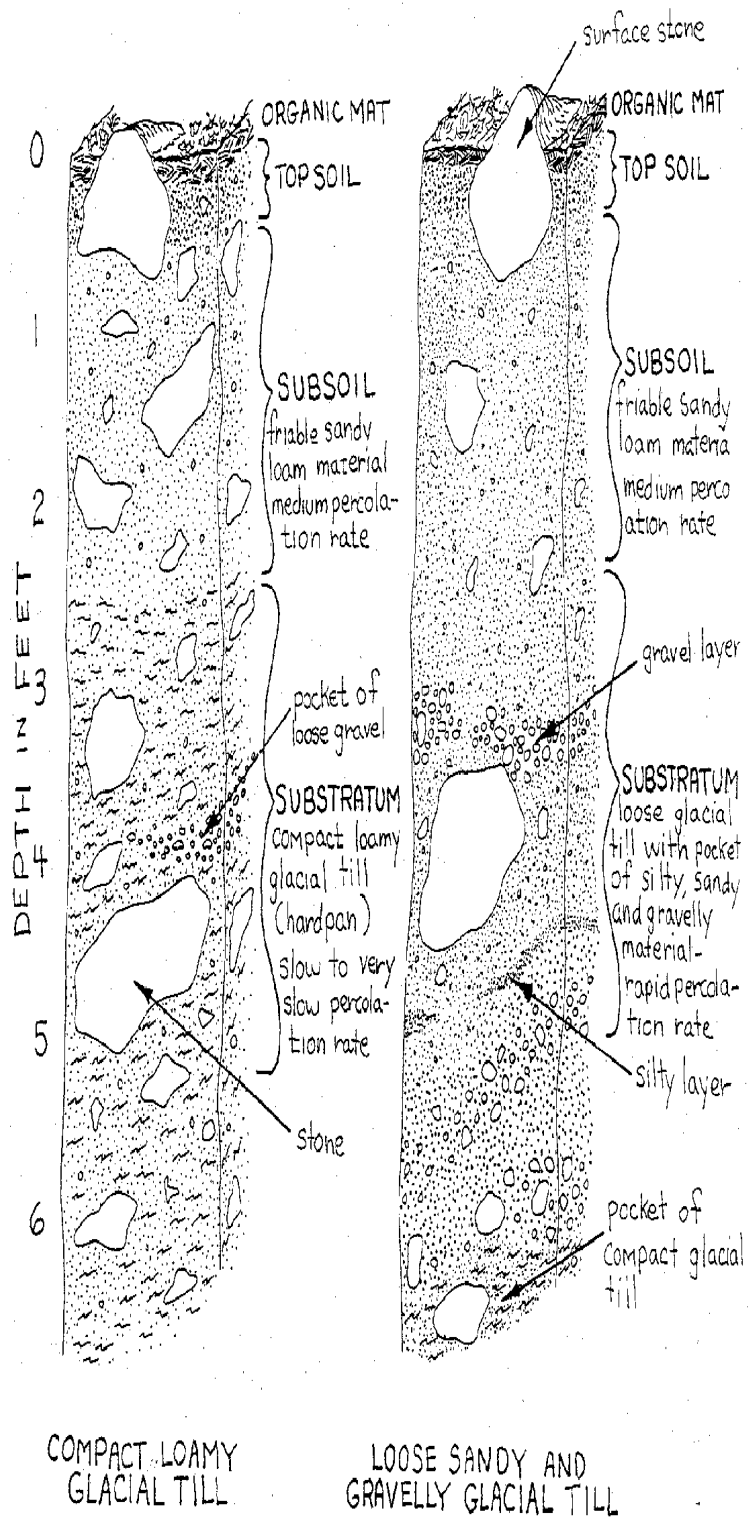
## **GLACIAL TILL SOILS**

As the glacier advanced over the area, it acted like a giant rasp. Stones and boulders frozen in the base of the glacier crushed and abraded the underlying bedrock. Unconsolidated debris beneath the glacier was transported and then later deposited across the landscape as the glacier gradually advanced southward.

Glacial till is a stony and bouldery material deposited by and underneath the glacier as it advanced over the area. It is predominantly unsorted and unstratified mineral material consisting of a heterogeneous mixture of clay, silt, sand, gravel, cobblestones, stones, and boulders. The chemical and physical characteristics of glacial till soils vary depending on the type of rock from which they were derived. There are two broad groupings of tills in Massachusetts: a silty and loamy compact till and a sandy and gravelly, loose, less compact till.

The **compact till** consists of loamy and silty materials that were deposited at the base of the advancing glacial ice. Soils developed in compact till generally have a friable surface and subsoil, and are underlain by firm, compact, slowly permeable material (locally referred to as hardpan) in the substratum.

The loose, **sandy and gravelly till** materials were deposited during the final stage of the last glaciation. Lenses of crudely sorted sand and gravel are common. Except for the presence of stones and boulders, this sandy and gravelly till is difficult to differentiate from ice-contact glacial outwash. Soils developed in this sandier till generally have a friable surface and subsoil, and are underlain by loose, sandy and gravelly material in the substratum or may also have a sandy compacted till which generally is much more permeable than the silty or loamy compact tills.



TYPICAL GLACIAL TILL SOILS

All glacial till soils in Massachusetts have varying degrees of surface and subsurface stones. Till areas that have not been farmed or developed generally have many stones and boulders on the surface. If the surface stones have been removed, the presence of stone walls and subsurface stones indicate areas of till soils. The stones are generally angular or sub-angular in shape.

Glacial till landscapes range from gently sloping and undulating areas to steep hilly areas. Landforms associated with till areas include:

1. Drumlin - a smooth, elongated oval hill (shape of an inverted teaspoon) of compact glacial till. Drumlins can be observed in most countries and are very common in some parts of Worcester County. Examples of drumlins can be seen while driving along the Massachusetts Turnpike.
2. Till Ridge - similar to a drumlin except it is more elongated and is a ridge rather than a hill.
3. Moraines - generally a wide belt of steep hills and ridges that mark the farthest advance of the glacier or a significant halt in its final retreat northward. The Sandwich and Buzzards Bay moraines on Cape Cod are examples of this landform.
4. Ground Moraines - till areas with no typifying topographic expression, generally undulating low lying hills. The relief of some ground moraine areas is influenced by the underlying bedrock surface.

### **Field Identification of Glacial Till Soils**

Soils that have developed in glacial till deposits exhibit the following characteristics:

1. Presence of angular and subangular cobbles, stones, and boulders on the surface and within the face of the deep observation hole.
2. The soil texture is variable and may range from gravelly loamy sand to silty loam. There is always enough silt and clay present to dirty the pores of one's palm when a moist sample is rubbed between the hands.
3. Soils developed in compact till generally have a friable surface and subsoil, and are underlain by firm, compact, slowly permeable material (locally referred to as hardpan) in the substratum. Depth to hardpan ranges from 20 to 48 inches. The hardpan is generally continuous with depth to the underlying bedrock. A field determination can be made by removing samples of undisturbed soil (fist size) at various depths. Then, by placing individual samples between the thumb and index finger one can gauge the resistance of the sample to fracture. Firm, compact glacial till (hardpan) is difficult to crush. Another field test for compact glacial till is to pick at the site of a pit with a large hunting knife. The blade can easily penetrate loose soil material but can only pick at compact till and will not fully penetrate the material to any appreciable depth.
4. The ease or difficulty of excavation with a backhoe is often a good indicator of the

presence of hardpan material. Dense, compact tills often cause a bucket to clatter across it rather than cutting deep into it. Lightweight machines often have difficulty reaching depths of 10 feet because of large boulders.

5. The color of glacial tills is variable and is dependent on the mineralogy of the rocks from which they were derived. Most tills are light grey or olive colored in the substratum, although some are reddish or even black.
6. Glacial till soils typically have no stratification or layering, although some tills may have pockets or discontinuous lenses of coarser or finer material. A few sandy and gravelly loose till deposits may have distorted bedding within the substratum.

### **Soil Assessment for On-site Sewage Disposal in Glacial Till Soils**

When conducting a soil evaluation within a glacial till area, the most important determinations to make are: is compact glacial till (hardpan) present, the depth at which it occurs, and whether it is continuous with depth.

In areas where there is compact glacial till (hardpan) special attention should be given to where the percolation test is performed. Tests should be done within the hardpan layer and not in the loose, more permeable upper soil material. Percolation rates within these areas are generally slow and often fail. Special care should be taken to clean the sides and bottom of percolation holes of any smeared surfaces and to fill the hole gradually so that the soil material is not stirred up. It should be remembered that till soils are naturally variable and may fail a percolation test in one area and pass in another part of the same lot.

The percentage of silt and clay within a glacial till has a significant effect on the compactness and permeability of the hardpan material. Tills with 5 to 10 percent clay are generally more permeable than those with 15 to 20 percent.

Perched water tables are common in soils with a hardpan. Following spring snow melt and after periods of heavy rainfall, water percolates at a moderate to rapid rate through the topsoil and subsoil, and collects on the surface of the less permeable hardpan creating a perched water table. If present, the perched water is generally observed weeping into the deep observation hole at the contact between the upper surface of the hardpan and the overlying loose soil material. Perched water tables are more prevalent on the lower portions of slopes and in nearly level or gently sloping till areas.

Even though a high water table may be present, compact glacial till transmits water so slowly that it typically weeps rather than flows from the walls of a deep observation hole. Groundwater elevation is the height at which water is observed weeping from the walls of a deep observation hole and it may take many hours for the level of standing water to rise to that height.

A special engineering design is generally needed to overcome the soil limitations in areas of compact glacial till. In soil areas where there is no hardpan and the substratum is loose and permeable, on-site sewage disposal systems generally function well when the water table is deep.

All glacial tills have some silt and clay. Construction within the leaching areas, especially

during wet periods, may result in compaction and smearing of the soil surface that reduces the natural ability of the soil to accept and transmit water. Special care should be taken to restrict vehicle traffic within these areas during construction and to clean the side wall and bottom areas with rakes and shovels to remove any compacted or smeared surfaces.

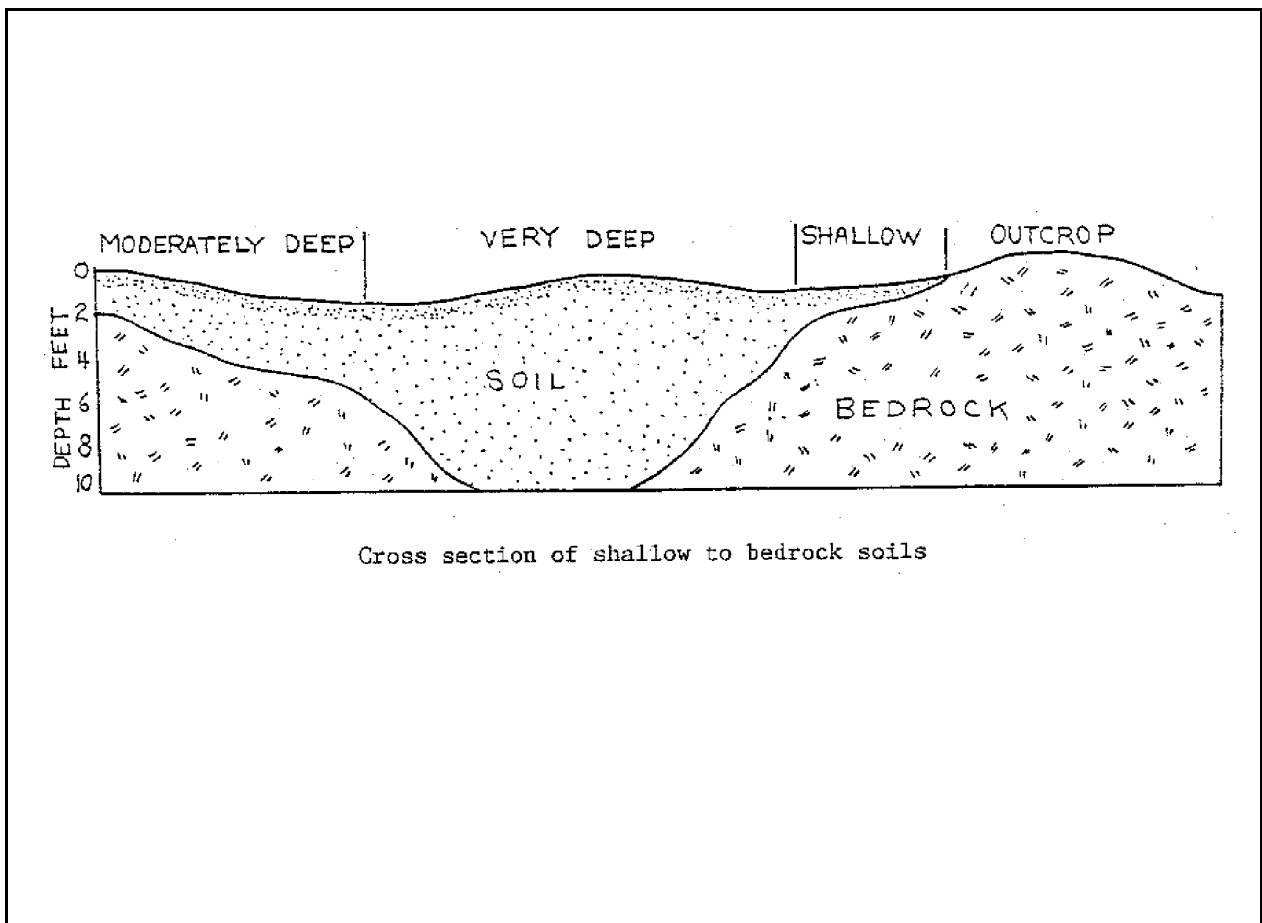
### **SHALLOW TO BEDROCK SOILS**

Generally in Massachusetts shallow to bedrock areas are a complex of rock outcrops (surface exposures of ledge), shallow to bedrock soils (10-20 inches of loose soil overlying bedrock), moderately deep soils (20-40"), and very deep soils (>60"). The unconsolidated soil material overlying the bedrock is generally glacial till but may be any one of the different types of glacial materials. Areas of shallow to bedrock soils are generally associated with surface exposures of bedrock. Bedrock areas have no distinguishing landforms but often occur as irregularly shaped knolls or steep ridges. Large surface boulders make it difficult to determine the presence of bedrock outcrops. The only accurate way to determine the depth to bedrock at a specific site is to excavate.

#### **Site Assessment for On-site Sewage Disposal in Shallow to Bedrock Soils**

Due to the uncertainty and variability of depth to bedrock, it is important that size evaluations be performed for each individual on-site sewage disposal system in the specific area where it is to be installed.

Systems installed in the areas where there is not a sufficient thickness (4 feet or more) of unsaturated, permeable soil material between the bottom of the leaching facility and the underlying bedrock risk potential failure. Untreated effluent may either collect on the surface of the underlying bedrock and possibly surface, or it may enter fractures with the bedrock and pass rapidly through the bedrock into the groundwater, posing a potential threat to groundwater quality. Some kinds of bedrock have a highly fractured zone of broken rock overlying solid rock. Where this fractured zone has little or no soil between the rock fragments, effluent will pass very quickly through it with little treatment. Because this fractured zone does not have the properties and benefits of a soil, it is considered the upper surface of the bedrock.



### **GLACIAL OUTWASH SOILS**

Approximately 20,000 years ago the climatic conditions changed and due to a warming trend the advancing glaciers began to melt and waste northward. During this process tremendous volumes of water were released from the glacier and melt water streams flowed outward from the ice terminus. Laden with debris from the glacier, these streams transported and then deposited sands and gravels out beyond the retreating glacier. These stratified deposits of sand and gravel produced by glaciers and carried, sorted and deposited by glacial melt water streams are referred to as glacial outwash. Glacial outwash landscapes vary greatly, ranging from nearly level plains to very steep hills and ridges. Landforms associated with outwash areas include:

1. Outwash Plains - a broad, nearly level plain deposited by melt water streams as they flowed out beyond the ice terminus. Most outwash plains have some steep sided depressions (kettle holes) resulting from where the outwash was deposited around and over stagnant ice, which later melted out leaving a depression. Outwash plains where kettle holes and kettle lakes are prominent features are referred to as pitted outwash plains.
2. Eskers - a long, narrow, sinuous, steep-sided ridge composed of sand, gravel and stones that was deposited by a subsurface stream flowing between ice walls or in

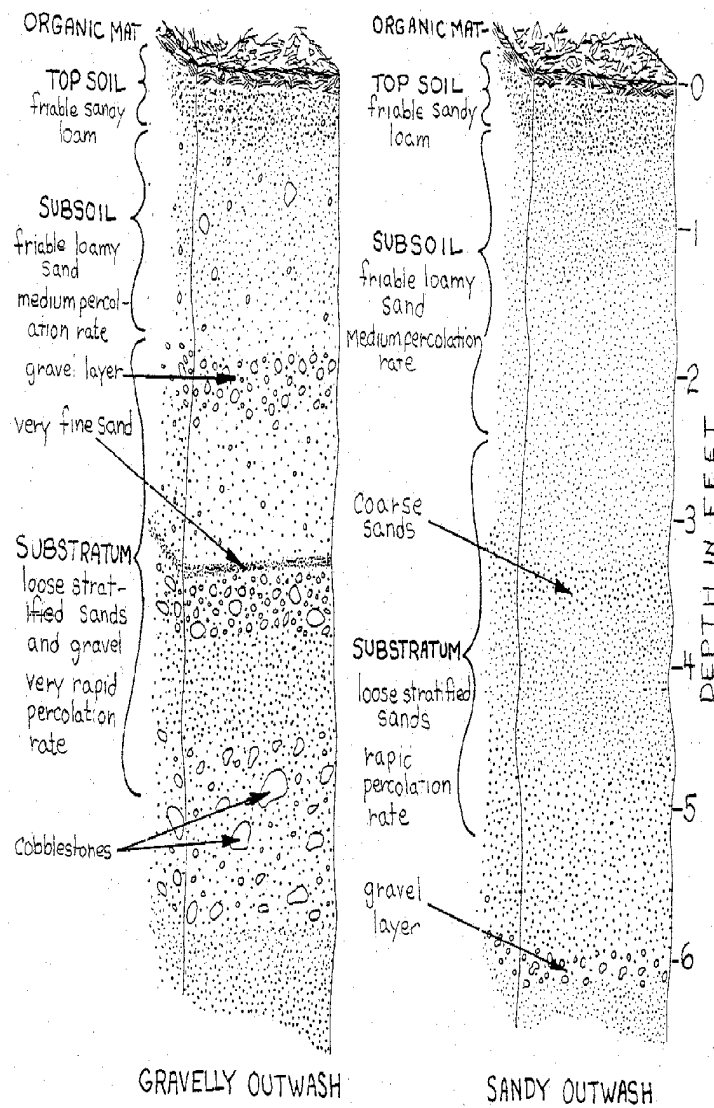
an ice tunnel of a retreating glacier, and remained after the ice left. Eskers range in length from less than a quarter of a mile to more than a mile, and in height from 15 feet to greater than 50 feet.

3. Kames - an irregular shaped hill of ice-contact glacial outwash, composed chiefly of stratified sand and gravel.
4. Kame Terraces - a terrace consisting of stratified sand and gravel deposited by a melt water stream flowing between a melting glacier and a higher valley wall and left standing after the disappearance of the ice. It is commonly pitted with "kettles" and has an irregular ice-contact slope.
5. Kame Delta - a flat topped steep sided landform consisting of stratified sand and gravel deposited by a melt water stream flowing from a glacier into a body of water. It is commonly pitted with "kettles" and has an irregular ice-contact slope.

### **Field Identification of Glacial Outwash Soils**

Soils that have developed in glacial outwash deposits exhibit the following characteristics:

1. Generally the largest rock fragments found in outwash deposits are rounded and subrounded cobblestones (3 to 10 inches in diameter). There are typically no surface and subsurface stones and boulders. Some steep hilly areas of outwash soils may have surface stones and boulders.
2. Generally within a depth of 24 to 36 inches there is either clean loose sand or stratified sands and gravel. When this material is rubbed between one's hands there is little if any silt or clay left in the pores.
3. Layering or stratification can almost always be observed in the walls of a deep observation hole.
4. The material in the substratum is loose and the sides of deep observation holes are unstable and often cave in. A person can easily dig into the side of a pit with his hands, and it is difficult to remove an undisturbed clod of soil from the wall of a deep observation hole. Backhoes seldom have any difficulty excavating in these areas and can easily reach depths of 10 feet or more.



TYPICAL GLACIAL OUTWASH SOILS

## **Soil Assessment for On-site Sewage Disposal in Glacial Outwash Soils**

Soil conditions within areas of glacial outwash are often uniform and may be consistent from one lot to another. This assumption can lead to serious mistakes, because some areas of glacial outwash are variable and may differ dramatically from lot to lot. Soil evaluations must be done for each individual on-site sewage disposal system in the specific area where it is to be installed. Many percolation rates within the loose sandy and gravelly substratum are very rapid and it is often difficult to maintain a water level within percolation test holes. Sandy textures in the substratum combined with a large percentage of coarse rock fragments (gravel and cobbles) may allow effluent to pass rapidly through the substratum and pose a threat to ground water quality. Outwash soils are recharge areas for groundwater and some areas are underlain by aquifers.

## **GLACIAL LAKEBED SOILS**

During the glacial retreat several extensive lakes were formed as the ice retreated northward and the outflow of melt water streams was blocked. These post glacial lakes existed for varying periods of time and many have since drained. At the time of their existence, melt water streams flowed into these lakes. Fine particles (silt and clay) that were held in suspension within these turbulent streams, settled out in the quiet waters of the lake and formed alternating layers of silt and clay (varves) at the lake bottom. These sediments were exposed when the lakes drained, and are referred to as lacustrine or glacial lakebed deposits.

Other areas of silty and clayey soils were formed in some coastal areas north of Boston. During and shortly after deglaciation, ocean waters inundated low lying areas of land along the shore. In a similar manner to the glacial lake deposits, silts and clays were first deposited beneath the ocean waters and later exposed when the land rose above sea level. These sediments are referred to as glacio-marine deposits.

## **Field Identification of Glacial Lakebed Soils**

Soils that have developed in glacial lakebed deposits exhibit the following characteristics:

1. Generally there is no gravel, cobbles or stones observed in deep pits.
2. There is a high percentage of silt and clay in these soils. Soil textures are generally loamy, very fine sand or finer.
3. Often, deep within the pit, there are alternating layers of silt and clay (varved deposit). Marine silts and clays, common to Northeastern Massachusetts, are not varved.

## **Soil Assessment for On-site Sewage Disposal in Glacial Lakebed Soils**

Soil conditions within glacial lakebed areas are variable. Soil evaluations must be done for each individual on-site disposal system in the specific area where it is to be installed. Percolation rates are generally very slow within these soils. Groundwater levels are often

high and should be checked during the wet periods of the year before installing a system. These soils have a high percentage of silt and clay. Construction within leaching areas, especially during wet periods, smears the soil surface and reduces the natural ability of the soil to transmit water. Special care should be taken to restrict vehicle traffic within these areas during construction and to clean side wall and bottom areas with rakes and shovels of any compacted or smeared surface after construction.

## **ORGANIC SOILS**

Swamp, bog and marsh deposits began to develop shortly after deglaciation. Many were originally shallow bodies of water, which with time, gradually filled in with organic debris.

Organic soil deposits are generally associated with low lying areas on the landscape and occur within depressions, at the base of swales, and in low lying areas adjacent to streams, ponds, and lakes.

### **Field Identification of Organic Soils**

Characteristics of soils that have developed in organic deposits:

1. Soil colors are very dark, generally black. Some areas have a reddish blue.
2. When a soil sample is rubbed between the fingers, you cannot feel any grittiness. If squeezed within one's fist, the organic material will ooze out between the fingers and has the consistency of mashed potatoes. When walking through an area of organic soil, there is a springy feel and not the solid feel associated with mineral soils.
3. When dried, samples of organic soil are very light weight.
4. All organic soils have either water on the surface, or a water table at or near the surface for most of the year.

### **Soil Assessment for On-site Sewage Disposal in Organic Soils**

The shallow depth to groundwater and low strength to organic material, are major reasons why these soils are poorly suited for on-site sewage disposal. Areas of organic soil are considered to be wetlands (hydric soil) and construction within these areas is often regulated by federal, state and local agencies.

## **ALLUVIAL SOILS**

Present day streams and rivers are continuing to alter the landscape as they erode and then deposit material. Flood plain soils, also referred to as alluvial soils, are formed when rivers overflow their banks during periods of flooding and deposit material adjacent to them.

Landforms associated with alluvial deposits include:

1. Floodplains - nearly level areas that border a stream and are subject to inundation under flood-stage conditions, unless protected.
2. Back-swamp - marshy, depressed areas of flood plains between the natural levee borders of channel belts and valley sides or terraces.
3. Meander Scar - generally crescent-shaped depressions that were once stream channels.

### **Field Identification of Alluvial Soils**

Soils that have developed in alluvial deposits exhibit the following characteristics:

1. These are recent geologic deposits and soils formed in them lack most profile development. Except for a darkened surface, these soils usually do not have distinct soil horizons. There may be buried surface horizons resulting from flooding and subsequent deposition.
2. Depending upon the water velocity at the time the alluvial soils were deposited, textures vary from gravel to silt, most being fine sandy loam or finer.

### **Soil Assessment for On-site Sewage Disposal in Alluvial Soils**

Areas of soil that are subject to periodic flooding (100 year flood plain) are generally considered to be unsuitable for development.

### **NATURAL SOIL vs. FILL MATERIAL**

Soil formation is a very slow process and, depending upon the specific site conditions, generally takes from 100 - 1,000 years before any visible effects are evident. For this reason, naturally occurring soil material is easily differentiated from fill material. Natural soils have a developed soil profile consisting of an organic mat, topsoil, subsoil, and substratum. The absence of this profile or the presence of a natural soil profile buried beneath other material, indicate an area of possible fill.

Areas of fill material generally lack a topsoil and bright uniform colors within the subsoil. Fill areas are often characterized by irregular stratification, abrupt unnatural changes in the soil material, mixed colors and flip flopped horizons. Also, the presence of man made materials such as bricks, glass, and metals buried within the soil profile is evidence of possible fill material.

### **SOILS WITH HIGH WATER TABLES**

Soils can be used to determine the presence and approximate elevation of a seasonal high water table, even during dry periods when the water table may be much lower. When a water table fluctuates within a soil it causes alternating saturated (reduced) and unsaturated (oxidized) conditions. The chemical reactions caused by these different conditions result in

color changes within the soil profile.

The coloration caused by a fluctuating water table within a soil is referred to as mottling. Soil mottles (redoxomorphic features) are variegated or irregular spots of orange, yellow and gray colors within the soil profile. The highest point that gray color mottles are observed in the soil is a clue for estimating the average seasonal high water table level. It is important to keep in mind that the highest point of distinct redox occurrence relates to the estimated average seasonal high water table. For any given year, the actual high water table may be higher than or lower than the average.

The amount of gray colors within an area indicates the duration of saturation. The more gray present, the longer the soil is saturated. A gleyed soil condition is one that results from prolonged periods of wetness, and the soil material is gray throughout with possibly only a few orange or yellow mottles. Increasing amounts of orange and/or yellow mottles indicate areas of soil that are saturated just during the very wet periods of the year.

"Rust line" is a term often used by health agents to describe a dark red layer or band in the soil that is often interpreted as being the maximum height of the water table. Bright red and yellow streaks can form within the soil through two contrasting processes that may or may not be the result of a high water table.

Those not associated with a water table may develop when percolating water is momentarily interrupted as it passes through different soil strata. This brief pause may cause dissolved iron within the water to precipitate out and over many years develop a bright red or yellow streak. This soil feature is common within some stratified sand and gravel deposits, and can often be observed on the sides of gravel pits high above any water table.

Only in a few unique situations do soils develop a rust line resulting from a fluctuating water table and they are the exception rather than the general rule. Rust lines associated with a water table are the result of a fluctuating water table and dissolved iron in the groundwater.

As the water table fluctuates, iron precipitates out forming a coating on the surface of soil particles and with time develops a bright red and yellow line in the soil. For a rust to be interpreted as an indicator of the maximum high water table elevation it should meet some or all of the following criteria: the rust line should appear as a nearly continuous band on all sides of the deep observation hole; it should be on a nearly level plane within the hole; soil mottling should be observed below the rust line; and in some situations dark nodules of hardened or cemented soil material are present within the rust line. In situations where the gray color occurs above a rust line, the height of the gray mottles should be interpreted as the height of the average seasonal high water table and not the underlying rust line.

A soil condition that exists in some wet areas is locally referred to as bog iron. Bog iron is a cemented layer within the subsoil that is dark red and in some instances almost black. This layer is difficult to penetrate and is generally only a few inches thick. Bog iron is formed by a fluctuating water table and indicates a wet soil. Gray mottles are not present within the bog iron layer but are generally observed either above or below it.

## **NATURAL SOIL DRAINAGE CLASSES**

Soils are divided into natural drainage classes depending on the frequency and duration of periods of saturation or partial saturation during soil formation. The major natural drainage classes recognized in Massachusetts are: excessively drained, well drained, moderately

well drained, poorly drained, and very poorly drained soils.

**Excessively Drained Soils** - have sandy and gravelly textures within the subsoil and substratum. They have bright colors (strong brown to yellowish brown) in the subsoil that fade gradually with depth. Seldom are there mottles within the upper 5 feet of soil material and water tables are generally greater than 6 feet.

**Well Drained Soils** - have bright colors in the subsoil that fade gradually with depth. These soils are free of mottling to depths greater than 48 inches. Water tables are generally greater than 6 feet.

**Moderately Well Drained Soils** - are mottled between 15 to 48 inches beneath the soil surface. Water is removed from these somewhat slowly; the profile is wet for a short but significant part of the year. Moderately well drained soils commonly have a restrictive layer, seepage water, or a seasonal high ground water table at a soil depth of 15 to 48 inches. Colors within the upper subsoil are bright and uniform. Mottling becomes noticeable in the lower subsoil and substratum.

**Poorly Drained Soils** - have seasonal high water tables 6 to 15 inches beneath the soil surface. Poorly drained soils have a dark (black) surface layer underlain by a gray subsoil that has yellow and orange mottles.

**Very Poorly Drained Soils** - have ponded water on the surface or a water table at or near (<6" below) the surface for most of the year. Very poorly drained soils can be divided into those that developed in mineral material and those that developed in organic material. Very poorly drained mineral soils have a dark (black) organic surface layer underlain by a gray (gleyed) subsoil and substratum immediately below the organic mat. Very poorly drained organic soils developed in thick, dark (often black) deposits of partially and well decomposed organic matter, and are black in the topsoil, subsoil and substratum.

## **SOIL TEXTURE**

Soil texture refers to the relative proportions of sand, silt, and clay in a mass of soil. Many different systems of describing and classifying soil texture are used. The systems differ depending on their intended use. There are several standard systems and many nonstandard ones. Standard systems include the USDA, UNIFIED, AASHTO, and FAA. When describing soils, it must be stated which system is being used. For example "clay" could be soil less than 0.002 mm, soil less than 0.006 mm, material that passes a #200 sieve or gray "sticky stuff." In this discussion, the USDA system will be emphasized since it is the most widely used for describing, classifying and mapping soils, and because it has application to a wide variety of uses.

In the USDA system, soil texture refers specifically to the relative proportions of the sand particles (2.0 mm - 0.05 mm) silt particles (0.005 mm - 0.002 mm) and clay particles (<0.002 mm) in the soil mass.

Sand particles can be seen with the naked eye and have a gritty feel to the fingers. The sand size particles can be subdivided into very coarse sand (2.00 - 1.00 mm), coarse sand (1.00 - 0.50 mm), medium sand (0.50 - 0.25 mm), fine sand (0.25 - 0.10 mm), and very fine sand (0.10 - 0.05 mm).

Silt size particles can be seen only with a hand lens or light microscope. They have a smooth powdery feel when dry and a slick creamy feel when moist or wet. Silt is not sticky. Silt size particles have a gritty feel when a small sample is placed between a person's front teeth. After handling silty soil samples a film will be left on the hands. For the most part, this film can be brushed off when it dries, leaving silt particles only in the pores.

Clay size particles can only be seen with an electron microscope. Clay feels greasy or sticky when moist or wet and is hard when dry. After handling clayey soil samples a film will be left on the hands and can only be removed with scrubbing.

Rock fragments are common in many New England soils and are divided by their size into gravel (2 mm to 3 inches), cobbles (3 to 10 inches), stones (10 inches to 2.5 feet), and boulders (greater than 2.5 feet).

Rarely do soils consist entirely of one size particle, meaning all sand, all silt or all clay. Generally soils are a combination or mixture of different size particles, and these different combinations are referred to as textural classes. There are many different textural classes. The basic textural classes usually encountered in Massachusetts in order of increasingly finer texture are: sand, loamy sand, sandy loam, loam, silt loam, silt, silty clay loam, and clay.

Textural class names provide a basis for making predictions of soil behavior. Although texture is probably the most important single characteristic used to predict soil behavior, other soil properties such as structure and consistence must be considered before an accurate judgment can be made. Soil texture is a primary consideration for predicting hydraulic conductivity, bulk density, water holding capacity, shrink-swell potential, frost action, subsidence, bearing capacity, compactability, infiltration rate, and erodability.

### **Feel and Appearance of Common Soil Textural Classes (1)**

<b>Soil Textural Class</b>	<b>Dry Soil</b>	<b>Wet Soil</b>
Sand	Loose, single grains which feel gritty Squeezed in the hand the soil mass falls apart when the pressure is released.	Squeezed in the hand, it forms a cast that crumbles when touched. Does not form a ribbon between thumb and forefinger.
Loamy Sand	Loose, single grains which feel gritty but enough fine but enough fine particles to stain finger prints in palm of hand.	Squeezed in the hand it forms a cast that crumbles when touched it forms a cast that crumbles when touched and only bears very careful handling.
Sandy Loam	Aggregates are easily crushed; very faint velvety feeling initially but with	Forms a cast, which bears careful handling

	continued rubbing the gritty feeling of sand soon dominates.	without breaking. Does not form a ribbon between thumb and forefinger.
Loam	Aggregates are crushed under moderate pressure; clods can be quite firm. When pulverized, loam has velvety feel that becomes gritty with continued rubbing. Casts bear rubbing. careful handling.	Cast can be handled quite freely without breaking. Very slight tendency to ribbon between thumb and forefinger. Rubbed surface is rough.
Silt Loam	Aggregates are firm but may be crushed under moderate pressure. Clods are firm to hard. Smooth, flour-like feel dominates when soil is pulverized.	Cast can be freely handled without breaking. Slight tendency to ribbon between thumb and forefinger. Rubbed surface has a broken or rippled appearance.
Clay Loam	Very firm aggregates and hard clods that strongly resist crushing by hand. When pulverized, the soil takes on a somewhat gritty feeling due to the harshness of the very small aggregates that persist.	Cast can bear much handling without breaking. Pinched between the thumb and forefinger, it forms a ribbon with a surface that tends to feel gritty when dampened and rubbed. Soil is plastic, sticky and puddles easily.
Clay	Aggregates are hard; clods are extremely hard and strongly resist crushing by hand. When pulverized, it has a grit-like texture due to the harshness of the surface. has a very smooth, of numerous very small aggregates which persist.	Casts can bear considerable handling without breaking. Forms a flexible ribbon between thumb and forefinger and retains its elasticity when elongated. Rubbed surface has a very smooth, satin feeling. Sticky when wet and easily puddled.

(1) U.S. Environmental Protection Agency, Design Manual-Onsite  
Wastewater Treatment and Disposal Systems

### **SOIL CONSISTENCE**

Soil consistence is the feel of the soil and the ease with which a ped or clod can be crushed by the fingers. Some of the terms commonly used to describe consistence are:

#### **1. Loose**

- a. Non-coherent when dry or moist
- b. Does not hold together in a mass

## **2. Friable**

- a. When moist, crushes easily under gentle pressure between thumb and forefinger.
- b. Can be pressed together into a lump

## **3. Firm**

- a. When moist crushes under moderate pressure between thumb and forefinger but resistance is distinctly noticeable.

## **4. Very Firm**

- a. When moist crushes under strong pressure between thumb and forefinger.
- b. Barely crushable

## **5. Plastic**

- a. When wet, readily deformed by moderate pressure but can be pressed into a lump.
- b. Will form a "wire" when rolled

## **6. Sticky**

- a. When wet, adheres to both thumb and forefinger
- b. Tends to stretch somewhat and pull apart rather than pulling free.

## **7. Hard**

- a. When dry, moderate resistance to pressure
- b. Can be broken with difficulty between thumb and forefinger.

## **8. Soft**

- a. When dry, breaks into powder or individual grains under slight pressure.

## **9. Cemented**

- a. Hard - soil particles bound together very strongly
- b. Little affected by moistening

## **SOURCES FOR GEOLOGY AND SOILS INFORMATION**

Surficial Geologic Maps published by the U.S. Geological Survey are prepared by geologists after extensive field work. Surficial geology maps delineate the various unconsolidated geologic deposits within an area and identify the different landforms.

There is often a brief narrative of the chronology of geologic events starting with the last

glaciation and leading up to the present. All of the surficial geologic quadrangle maps for Massachusetts have not been mapped. There are many different kinds of geologic maps available and people looking for this kind of information should contact the U.S. Geological Survey in Marlborough, Massachusetts.

Soil Survey Reports published by USDA - Soil Conservation Service are prepared by soil scientists who have traversed the landscape and have dug holes to identify the different soil types. These reports contain soil maps, a narrative section, and tables. The soil maps are on an aerial photo base and delineate the different soil types. The narrative section explains how to use the report and describes the different soils that were mapped. The Tables section lists many of the physical and chemical properties of the soils. Interpretive tables rate the soils for many different uses, one of which is Septic Tank Absorption Fields. All of Massachusetts is soil mapped and County Soil Survey Reports are available in many areas. People looking for soils information should contact either their local USDA - SCS or the State Headquarters located at 451 West Street, Amherst, MA 01002.

### **DRAINAGE - SURFACE AND SUBSURFACE**

Drainage onto or into the area of a leaching facility can flood the facility and result in a failure of the system. Drainage may result from rainwater runoff coming from a higher elevation, or from a ditch or drain from elsewhere on or off the property. In siting a proposed leaching facility, care should be taken to avoid locating the facility in a low area that is likely to collect runoff of water from ditches. Underground drainage, or a perched water table, can be intercepted and diverted away from the leaching facility by means of interceptor drains, or curtain drains. These drains consist of trenches cut into the hillside, or area of higher elevation, and are generally placed at right angles to the flow of the underground drainage. They intercept the water before it reaches the immediate area of the leaching facility and divert it to another location. The trenches are filled with stone or at least the section of the trench at the elevation of the underground drainage contains stone over which soil may be backfilled. Title 5 requires that a distance of 25 feet be maintained between any surface or subsurface drain that intercept seasonal high groundwater and a septic tank. The required setback is 50 feet to a soil absorption system. (see 15.211)

### **WETLANDS AND FLOOD PLAINS**

Many cities and towns in Massachusetts have designated areas as "wetlands" under local by-laws. In addition, the State has authority under the Wetlands Protection Act. The appropriate section (MGL, Chap. 131, Sec. 40) gives local Conservation Commissions jurisdiction over groundwater protection. Wetland areas include wet meadows, bogs, marshes, swamps and areas where groundwater flowing or standing provides a significant substrate for a plant community for at least five months of the year. Cities and towns have also passed by-laws for the protection of Flood Plains. Aquifer Recharge Areas, Water Resources Protection Districts and a number of other by-laws for the protection of sources of water. Boards of Health should be aware of those areas of the community that are protected by city and town by-laws so that the board does not issue permits for the construction of leaching facilities in a protected zone or within distances specified under a by-law. Title 5 does not prohibit the location and construction of a subsurface sewage disposal system in a flood plain. The code does, however, require that specific setbacks

be maintained between the septic tank and soil absorption system and bordering vegetated wetlands, salt marshes, inland and coastal banks, and certified vernal pools. Section 15.211 should be consulted to identify these distances.

## **WATER SUPPLIES/WATER COURSES**

Lakes, ponds, reservoirs, wells and other sources of water supply are vital to our subsistence and must be protected from human sewage. Water bodies not necessarily used as water supplies must likewise be protected from contamination by human sewage.

Title 5 defines a water body as "all waters within the jurisdiction of the Commonwealth, including, without limitation, rivers, streams, lakes, ponds, springs, impoundments, wetlands, estuaries, coastal waters, groundwaters, and vernal pools." Section 15.211 of Title 5 lists distances that must be maintained between the components of a subsurface sewage disposal system (septic tank and soil absorption system) and a well or suction line, a water supply line (pressure), surface water supplies (reservoirs or tributaries to reservoirs, including open and subsurface drains) and watercourses (see Figure 4-4).

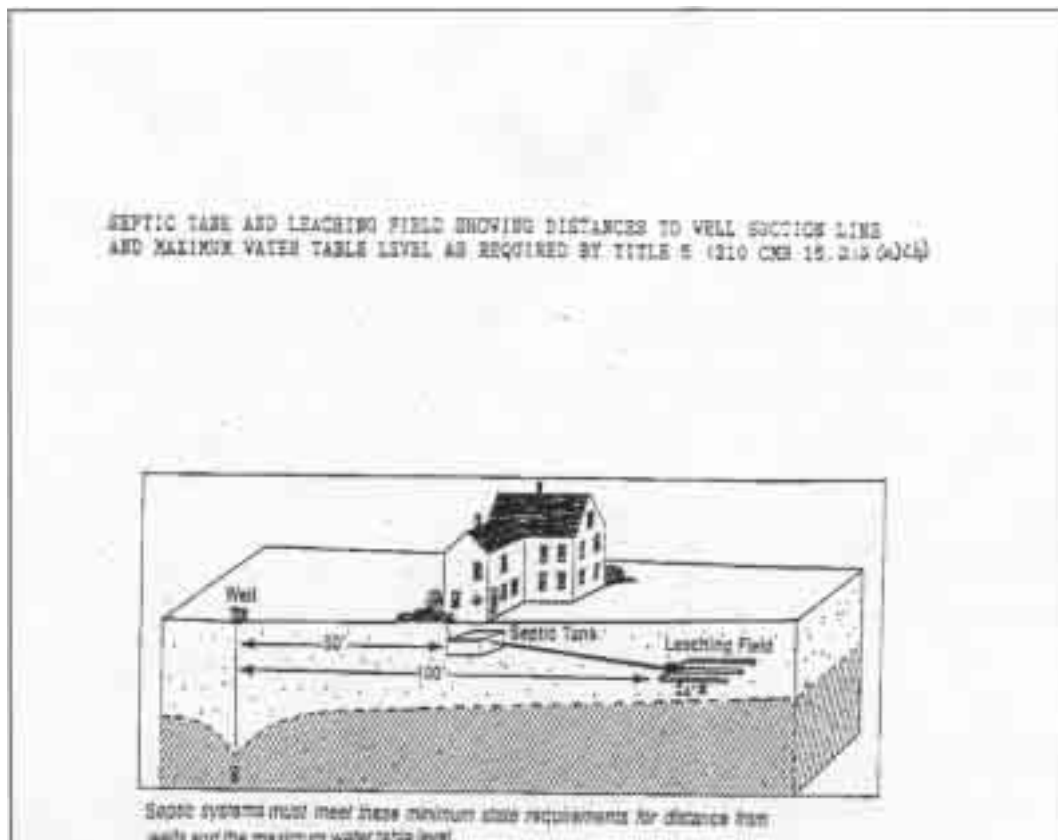


Figure 4-4

## **GROUNDWATER AND DETERMINATION OF MAXIMUM ELEVATION**

The presence of high groundwater can be one of the most troublesome factors in the design, construction, operation and repair of a subsurface sewage disposal system. A sizeable proportion of all such system's failures, in most communities, can be attributed to high groundwater, or more specifically seasonally high groundwater. The Board of Health,

therefore, should gain an understanding of groundwater including how, when and where to look for it.

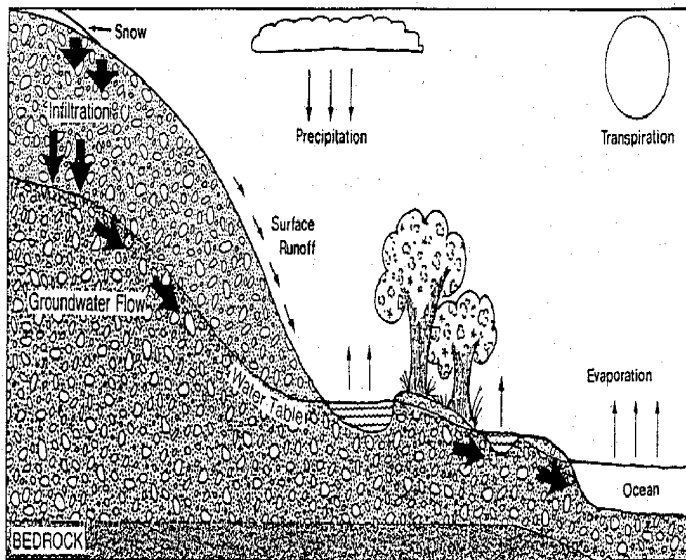
Water moves underground through the soils of the earth as one link of the "hydrologic cycle" which is continuous circulation of water between the oceans, the atmosphere and the land. Water from the oceans evaporates into the atmosphere where it forms into clouds that in turn produce precipitation in the form of rain and snow. A portion of the precipitation results in an overload runoff to feed rivers, lakes and streams, while some water infiltrates the soil to become groundwater. The surface water and groundwater eventually reach the ocean or are returned directly to the atmosphere through evapotranspiration (see Figures 4-5 & 4-6).

The underground water, resulting from precipitation infiltrating the soil, fills the voids between soil particles and crevices in bedrock to form a continuous saturated zone at the level where all such voids and crevices are filled. The upper level of this saturated zone is called the "water table" or "average water table." However, the maximum groundwater elevation may rise well above this average water table in the wettest months of the year. Conversely, during the driest months of the year, a seasonal water table may be below the average water table (see Figure 4-7).

Immediately above the water table, or upper level of the zone of saturation, is an area called the capillary fringe where water is taken up into the openings in the soil by capillary action. The capillary fringe area usually extends a few inches above the water table, but may extend two or three feet above the water table. This area may look moist in an excavation for a deep observation hole yielding groundwater, but can be distinguished from the water table as the groundwater rises in the hole to the elevation of the water table.

Board of Health inspectors will sometimes encounter a condition called "perched groundwater" which may be confused with the natural water table. Perched groundwater, or a perched water table, occurs when water, infiltrating the soil from above, reaches an underlying layer of impervious, or relatively impervious soil that restricts its downward movement. The water accumulates or becomes perched on the impervious soil. The perched water may move laterally seeking a pervious soil or lower elevation. A deep observation hole, excavated through a perched water table, may accumulate water and give the appearance of being excavated into the water table. If the water enters the observation hole at a high elevation, in an area not known for high groundwater, perched groundwater should be suspected. However, additional observation holes should be excavated or further investigation conducted to confirm, or rule out, perched water and to determine the elevation of the natural water table. Perched water entering an observation hole at a deep elevation may be confused with the natural water table if no further investigation is made. Perched water can result from a heavy rain fall and then disappear in a matter of hours, but in ground containing a very dense layer of soil the water may remain perched for months during the wet season. Perched water can be controlled through the use of interceptor or curtain drains described under "Drainage – Surface and Subsurface."

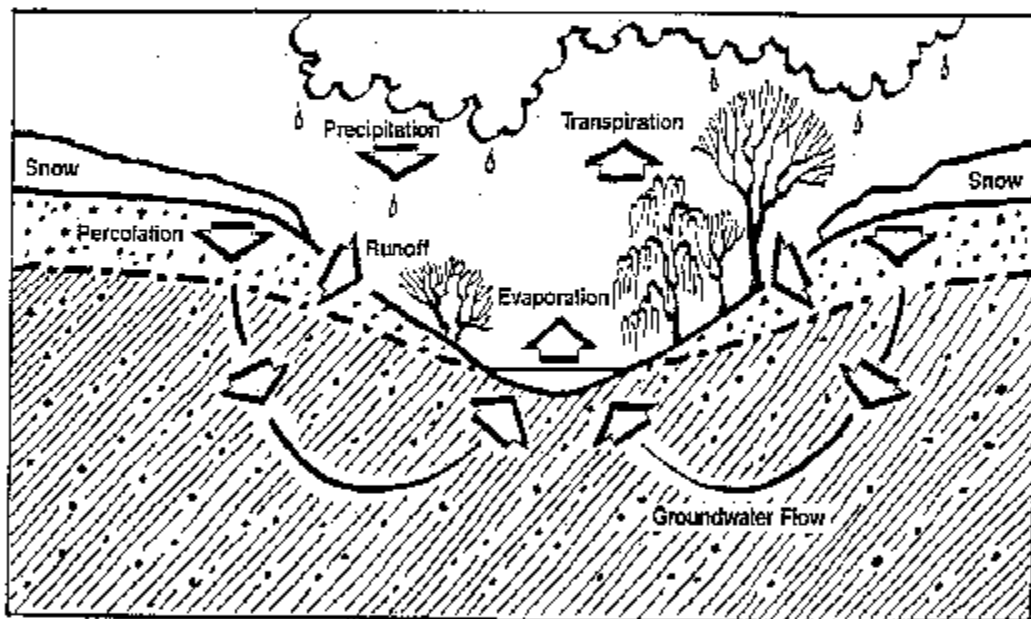
Diagram of the Hydrologic Cycle  
(Coastal environment)



*The source of all groundwater is precipitation. Groundwater is part of the water cycle.*

Figure 4-5

Diagram of the Hydrologic Cycle  
(Inland Environment)



*Groundwater is part of the hydrologic cycle; groundwater and surface water are interconnected.*

Figure 4-6

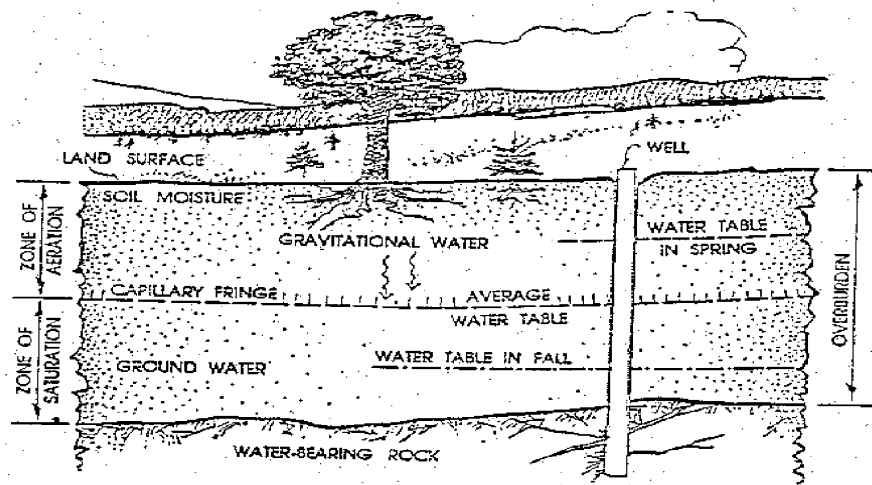


DIAGRAM SHOWING THE HIGH, LOW AND AVERAGE WATER TABLE ELEVATIONS

Figure 4-7

Title 5 requires that the minimum vertical separation distance of the bottom of the stone underlying the soil absorption system above the high ground water elevation be at least four feet above the maximum groundwater in soils with a recorded percolation rate slower than two minutes per inch and five feet in soils with a recorded percolation rate faster than two minutes per inch (15.212). Title 5 also requires that the invert elevation of outlets of grease traps be at least one foot above maximum groundwater. This is also a good idea for other components of on-site systems such as the septic tank, d-box, and dosing tanks. It is necessary, therefore, to determine the elevation of high groundwater before approving any design, construction or alteration of an on-site treatment and disposal system.

The best way to determine the maximum groundwater elevation is to conduct deep observation hole examinations during the wettest months and directly observe the elevation of the water. However, this may not always be practical for either the Board of Health or the land owner, because of scheduling commitments, personnel constraints or the weather. There are some other indicators of seasonal high groundwater that can be useful in determining the maximum elevation. One method used by soil scientists to determine the seasonal maximum elevation of groundwater is the examination of soil mottling. Soil mottling is a characteristic of some soils when exposed to groundwater. Contrasting colored patches appear in the soils due to an oxidation process as the groundwater rises. Colors include various shades of orange, red and grey. Evaluation of soil mottling to determine seasonal maximum groundwater elevation must be conducted by a certified soil evaluator.

Wetland vegetation and shallow tree roots are also indicators of possible seasonal high groundwater. Boards of Health should become familiar with areas of the community where high seasonal groundwater has been established and should keep file records of such readings. Also, Boards of Health should require the use of monitoring wells in areas where seasonal high groundwater is suspected, but the probable maximum elevation has not been determined. Monitoring wells are easily constructed. Guidance for the installation of these wells is provided in the appendix of this manual. The elevation of the groundwater can be measured periodically over several weeks, or months, using a tape measure or a string and a float. The location of the holes, date and water elevation must be recorded and retained in the Board of Health files.

## **NITROGEN SENSITIVE AREAS**

The revised Title 5 now contains new requirements for enhanced treatment in important areas referred to in the code as "Nitrogen Sensitive Areas". These areas are determined by DEP to be particularly sensitive to the discharge of pollutants from on-site sewage treatment and disposal systems. Areas so designated include Interim Wellhead Protection Areas (IWPAs), mapped Zone 2s of public water supplies, and nitrogen sensitive embayments.

**Interim Wellhead Protection Areas** or IWPAs are specifically defined in the Massachusetts drinking water regulations, 310 CMR 22.02. Generally, this is a 1/2 mile radius for groundwater drinking water sources whose approved pumping rate is 100,000 gpd or greater. For smaller sources, the radius in feet is determined by multiplying the approved pumping rate in gallons per minute by 32, and adding 400. IWPAs are only used as a guideline in the absence of an approved Zone 2 delineation.

**Zone 2** areas are those areas of an aquifer which contribute water to a well under the most severe pumping and recharge conditions that can be realistically anticipated. These areas are designated by the Department based upon actual pumping and field conditions and computer model projections. You should contact your regional DEP office, Division of Water Supply, for delineated Zone 2s in your town.

Presently there are no designated **nitrogen sensitive embayments** on record at DEP. It is anticipated that areas will be so designated in the future, thus the reason for inclusion into the code. In order for an embayment to be designated, scientific evaluations of the affected embayment will have to be conducted and the designation must be adopted through parallel public hearing processes to revise both Title 5 and the Massachusetts Water Quality Standards (314 CMR 4.00).

The significance of this section of the regulations is quite simple. The DEP wishes to protect these areas from increases of nitrate to the drinking water system and for embayments to protect the embayment from eutrophication as a result of excessive nutrients. In order to accomplish these goals the new code sets limits on the amount of nitrogen (also referred to as nitrogen loading) that can be discharged from on-site systems. The rules essentially require an acre of land for construction of a new four bedroom home. A larger house or a smaller lot may be allowed if a higher level of treatment, such as a

recirculating sand filter, is provided. In addition, the code also allows a averaging of the nitrogen load across the full size of a project, or on a regional or community basis under certain conditions. Readers are referred to section 15.216 for additional information on this topic.